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PNF AND OTHER FLEXIBILITY TECHNIQUES

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Abstract

Effective flexibility procedures are one of the essential tools by which excellence can be attained. Although stretching exercises provide obvious benefits, negative outcomes can result unless effective stretching procedures are incorporated. Characteristics of effective stretching include warmup before stretching, stretch before and after exercise, stretch slowly and gently, hold a minimum of 10 seconds, stretch to a point of tension (not pain), and relax. Furthermore, the primary target of flexibility exercise is connective tissue. Effective procedures control sensory mechanisms by inhibiting muscle spindle receptors and stimulating Golgi tendon organs resulting in less resistance to stretching soft tissue. Modified proprioceptive neuromuscular facilitation (PNF) flexibility techniques have been found to significantly increase joint range of motion over that of the static and other conventional techniques.

PNF AND OTHER FLEXIBILITY TECHNIQUES

Flexibility or joint range of motion exercise has been used in movement oriented programs for years, but there appears to be an increased interest in its multifaceted benefits. Although there are numerous sources which espouse the value of flexibility and the diverse role it plays, many appear to rely on conveying personal experiences rather than on studies based on scientific data. Make no mistake, however, there are many sound investigations reported in the professional literature that lead us to concluding that there is significant value in participating in an effective, regular, and comprehensive flexibility program.

Characteristics of Effective Stretch

Although stretching exercises provide obvious benefits to the individual involved in an active fitness and athletic program, negative outcomes can result unless careful, scientifically substantiated stretching procedures are incorporated. The following are common characteristics related to effective stretching techniques:

1. Warmup before stretching
2. Stretch before and after exercise program
3. Stretch slowly and gently
4. Hold stretch position a minimum of 10 seconds
5. Stretch to a point of tension, NOT pain
6. Relax while stretching

A general warmup should precede the stretching session. Approximately five minutes of light, large muscle activity such as walking, jogging and calisthentics can be included. All parts

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of the body should be involved in order to prepare an individual for stretching by increasing the body temperature and blood flow. According to Sapega, Quedenfeld, Moyer, and Butler (1981) soft tissues are elongated more effectively and safely when stretching occurs while the tissue temperature is higher. Colder soft tissues, or tissue temperatures that are normal or below normal, respond less favorably to stretch and are more susceptible to injury.

Benefits can also result when flexibility exercises are repeated subsequent to the main portion of the workout. Light activity such as walking and jogging followed by stretching exercises are considered to be an effective cool down. Tissue temperatures are highest following a strenuous workout and stretching can be accomplished more effectively. In addition, the soreness that sometimes results from a vigorous workout tends to be minimized. The build up of metabolic products from a hard workout which pool in the muscles are a source of the discomfort. Proper stretching procedures during the cool down can help in clearing the muscle metabolic products and reduce pooling.

A slow, gentle S-T-R-E-T-C-H is the basis of a safe program and is present in all effective, contemporary flexibility techniques. Gentle stretching performed slowly has been found to assist in injury prevention and in the reduction of tissue soreness. Quick or ballistic movements should, therefore, be discouraged in all flexibility programs.

A static or motionless stretch should be held for a minimum of ten seconds and at a point of perceived tension. Elongation

of the tissues to a point where pain is felt will only result in adding muscle tension and negative outcomes, such as soft tissue tearing, unwanted muscle contraction and resistance to stretch. Stretching, therefore, should never exceed mild discomfort. Successfully coupling relaxation with effective procedures is very important. This can result in improved tissue elongation and positive outcomes. Focus on what you feel during the stretch. After experiencing a reduction in tissue tension at or near ten seconds, it is often possible to further lengthen soft tissue by maintaining a relaxed stretch for 30 to 60 seconds. Benefit in longer time intervals sometimes occurs because tension from the stretch can bring about a phenomenon (inverse myotatic reflex) which allows muscle tissue to further elongate. Very positive results can be obtained, however, in a ten second static stretch. The lesser time interval has obvious benefits in the hurried schedule of an individual.

Connective Tissue

Connective tissue is the primary physical target of range of motion exercise, whether in rehabilitation following injury or in a flexibility program for normal individuals. Therefore, it is important that we deal with some of the physical properties of connective tissue.

Makeup and arrangements. Connective tissue is made up of collagen fibers embedded in a protein-polysaccharide matrix. Collagen has a very high tensile strength and resistance to stretch. These collagenous tissues are organized into many different structures, including tendons, ligaments, joint capsules, fascia, Aponeurosis, and others. Range of motion in

most body joints is primarily limited by one or more connective tissue structures. Sapega, et al. (1981) suggested that muscles are not predominately connective tissue as are tendons and joint capsules. When a relaxed muscle is stretched, most of the resistance to stretch is derived from the extensive connective tissue framework and sheathing within and around the muscle such as fascia. Furthermore, Casella (1950) and Stolvo and Wellepp (1966) indicate most resistance does not come from myofibrillar elements.

Therapeutic circumstance and connective tissue. Following tissue trauma or surgery, connective tissue involved in the body's repair process frequently impedes normal function. Common types of pathological connective tissue to be dealt with therapeutically are scar tissue, adhesions, and fibrotic contractures.

Types of connective tissue stretch. Because connective tissue is the most important physical target of range of motion exercise, it is important to understand the physical factors that influence the mechanical behavior of connective tissue under stretch. Therefore, an understanding of elastic and plastic tissue behavior is essential.

Elastic stretch. Elastic stretch represents a spring-like behavior. Tissue elongates when loading is present. However, the elastic properties in connective tissue are recoverable. Therefore, elongation is temporary. The engineering community would liken this characteristic to a spring element. In fact, the term "elasticity" means to return to normal length.

Plastic stretch. Plastic stretch represents a putty-like behavior. When stretching the tissue, viscous properties allow the linear deformation to remain following the stretch. Therefore, more permanent elongation occurs. A similar example would be a hydraulic cylinder representing the viscous elements.

Combination of qualities. Connective tissue under tensile stress behaves in a visoelastic manner. In other words, both elastic and plastic qualities are represented when stretched. Sapeqa, et al. (1981) suggests that collagenous tissue when stretched behaves as if it has both viscous and elastic elements connected in series. Under stretch, the relative proportion of elastic and plastic deformation can vary widely depending on how stretching is performed and under what conditions tissue elongation is performed.

Principle factors involved. The principle factors involved when stretching connective tissue are in the magnitude, duration and temperature of tissue during stretch. These factors influence the proportion of plastic and elastic stretch. Procedures for elastic stretch and recoverable deformation involve a high stretch magnitude, a short stretch duration, and a tissue temperature of normal or cold termperature. Procedures for plastic stretch and more permanent lengthening incorporate a lower stretch magnitude, a longer stretch duration, and a warmer tissue temperature.

Common Flexibility Techniques

Before discussing recognized flexibility techniques, it is important to understand several basic musculotendinous sensory receptor considerations relevant to increasing flexibility.

Proper stretching procedures lend themselves to positive soft tissue reactions. By understanding important sensory implications to stretch, it is easier to comprehend why a technique is effective.

Quickly stretching a muscle causes sensitive muscle spindle receptors to fire, resulting in muscle contraction (causing shortening) of the muscle tissue being stretched. This is known as a stretch reflex. Normally the stretch reflex is beneficial in sports and fitness activities because it aids in protecting tissues from being overstretched. However, if effective stretching is to be accomplished, it is essential that muscle reflex contractions be kept to a minimum. Fast stretching procedures increase the ammount and rate of the stretch reflex and should not be a part of a flexibility program. The chance of tissue tearing and soreness increase with ballistic and painful maneuvers. Connective tissues (tendons and ligaments) are vulnerable to strain because of the magnitude of the force created during these maneuvers.

Static stretch. The static flexibility technique incorporates a stationary position with tissues held at a greater than resting length. Although the static stretch can be an integral part of several different types of maneuvers, it can be used quite effectively without assistance from a partner and as a single maneuver. There are a number of advantages to its use. It can be done safely by most individuals with minimal instruction and has been found to establish a relaxed environment for lengthening soft tissues. Beaulieu (1981) suggests that if

done gently and slowly, the static stretch produces low muscle (EMG) tension and is safer than most stretching techniques. Cornelius (1983) found, however, no difference between static and modified proprioceptive neuromuscular facilitation flexibility techniques in electrical activity elicited from the muscle. Consequently, because of the low incidence of injuries to the soft tissues, the ease with which it can be performed and its effectiveness, the static stretch may be recommended for the non-athletic individual and can be effective as well for athletes.

Passive, static stretch (with partner). The passive, static stretch technique is similar to the static stretch. A primary difference lies in the use of a partner. There is a working relationship between the partner and person being stretched. The entire sequence is done passively with partner assistance. Use of the passive, static stretch technique can be safe when the working relationship has been established. Because soft tissue may be stretched beyond desired length when individuals are careless, it is essential that the point at which tension is felt be quickly communicated. Supervision and training are recommended in order to provide participants with the assistance necessary to keep musculotendinous injuries at a minimum. The partner simply applies a slow, gentle external force to the segment being stretched and then assists in maintaining the point at which tissue tension is felt.

Ballistic stretch. The ballistic stretch technique utilizes a repeated bouncing action or percussive effect and should be discouraged. Quick and forceful movements intensify the magnitude of associated stretch reflex contractions. Although

increased flexibility can be achieved with ballistic streching, it is often accompanied by injury and soreness.

MODIFIED PROPRIOCEPTIVE NEUROMUSCULAR FACILITATION (PNF).

Holt (1976) and Holt, Travis and Okita (1970) suggest that PNF techniques used in current flexibility methods were basd on therapeutic principles used by Herman Kabat for paralytic patients. Wendell and Decker (1962) reported that PNF techniques were developed from 1946 to 1951 at the Kabat-Kaiser Institute. Physical therapists have used PNF techniques in treating patients with neuromuscular paralysis. Knott and Voss (1968) have defined PNF as a method "of promoting or hastening the response of a neuromuscular mechanism through stimulation of the proprioceptors" (or receptors). It is from this background that modified PNF stretching techniques have evolved. Holt, et al. (1970) described PNF stretching techniques as being based on the principles of successive induction (involves maximal isometric contraction of the stretched muscle, agonist, followed by a concentric contraction of the antagonist), muscle relaxation, and reciprocal inhibition (involves concentric contraction of the antagonist and relaxation of muscle being stretched, agonist). Early literature relating to the use of PNF emphasized the need for working in diagonal patterns which can involve greater variety of soft tissue, while in recent years, the literature has reported studies utilizing pure movements uniaxial and in a single plane. There is no doubt that modified PNF flexibility techniques can become a significant force in the evolution of improved joint range of motion for contemporary sports and

fitness programs. Holt, et al. (1970); Tanigawa (1972); Cornelius and Hinson (1980); and Prentice (1983), suggest that PNF is simply more effective in developing ROM than the widely used static stretching technique.

Advantages of PNF techniques. The primary advantage to the use of PNF flexibility techniques lies in their effectiveness at creating an internal atmosphere conducive to stretching soft tissue by controlling sensory mechanisms. PNF stretching techniques are designed on the basis of a gentle, passive prestretch (e.g. partner assisted initial stretch maneuver) and subsequent muscle contraction terminated by a passive, static stretch. Two sensory mechanisms that are manipulated in effective stretch techniques are muscle spindle receptors and Golgi tendon organs. By using PNF techniques, muscle spindles are inhibited and Golgi tendon organs are stimulated. Muscle spindle inhibition results in less resistance to muscle elongation and Golgi tendon organ stimulation allows muscle tissue to be further elongated.

Spindle stimulation is associated with resistance to optimum tissue length because muscular adjustments are made in the form of reflex shortening (stretch reflex or myotatic reflex). Consequently, the use of slow, passive stretching combined with subsequent agonist and/or antagonist muscle contraction produces Golgi tendon organ stimulation. This phenomenon has a positive influence by allowing for soft tissue length to be further increased resulting in improved joint range of motion. Thus, the stimulation of Golgi tendon organs results in a stretch reflex inhibition (inverse myotatic reflex).

Muscle spindle receptors. Muscle spindle receptors are very specialized receptors that are sensitive to muscle length and rate of change in length (velocity of muscular contraction). The spindle is located in the muscle bundle in a wide distribution which suggests the whole muscle is sensitive to stretch. Inside each spindle are about six muscle fibers (intrafusal fibers). This is not to confuse these intrafusal fibers with skeletal muscle fibers (extrafusal fibers). A stretch of the intrafusal fibers is caused by a lengthening of the extrafusal muscle fibers. Therefore, spindles respond to stretch of individual muscle fibers. During spindle stimulation, a stretch reflex occurs, resulting in nerve impulses directed to the spinal cord by afferent nerve fibers where direct contact is made with the alpha-motorneurons. The alpha-motorneurons facilitate contraction of the same muscle and selected synergestic muscles (cooperative muscles) in which the stretch occured. Opposite (antagonist) muscles are inhibited (relax). Incorrect flexibility procedures can cause stimulation of the muscle spindle receptors and may result in muscle contraction of the muscles to be stretched. Examples of ineffective procedures are:

1. Repeated stretching beyond a comfortable tissue length
2. Assuming a painful stretching position
3. Ballistic or quick stretching maneuvers

Golgi tendon organs. The Golgi tendon organs (GTO) are found in musculotendinous junctions and are stimulated by a process of deformation due to tension in the tendon. Matthews and Fox (1976) and Guyton (1981) refer to the GTO's as muscle

tension sensors. These tendon organs are specialized projections of collagenous connective tissue surrounded by a thin capsule, which contains sensory nerve endings projecting to the spinal cord. Furthermore, these afferents send impulses to interneurons, which in turn inhibit alpha-motorneurons in the same or synergestic muscles and facilitate alpha-motorneurons in the antagonist muscles. Like muscle spindles, GTO's can be stimulated by stretch. However, spindles are activated easier than the tendon organs. GTO's require a strong stretch before they are stimulated. The GTO's lie in the tendon, and therefore, they are activated when the series of associated muscle fibers contract and create a stretch of the tendon. When GTO's are stimulated, sensory information is sent to the central nervous system (CNS) causing the contracted muscle to relax.

Astrand and Rodahl (1970) noted that GTO's were stimulated during both a passive stretch and an active contraction of the muscle. Cooper and Glassow (1976) suggested pressure on the nerve endings from the stretch of connective tissue initiated the transmission of afferent nerve impulses. Tanqawa (1972) concluded the combined tension created by a maximum isometric contraction and the lengthened soft tissue added to the ability of the GTO's to be stimulated. According to Astrand and Rodahl (1970) and Taniqawa (1972), the GTO's initiated afferent nerve impulses when stimulated causing reflex inhibition of the agonist. Modified PNF procedures, therefore, have a positive influence on sensory mechanisms and according to Cornelius (1983), maintain low muscle tension during the terminal

stretching maneuver.

Disadvantages of PNF techniques. There appears to be several commonly perceived disadvantages to the use of modified PNF stretching techniques. Initial practice and supervision are necessary in order to maintain maximum effectiveness and safety. Also, the assistance of a partner is required in PNF techniques because there is the incorporation of an initial passive stretch, resistance applied for the isometric contraction, and a final passive stretch of the agonist joined with a concentric contraction of the antagonist.

Hold-relax. The Hold-relax flexibility technique is initiated by a passive prestretch maneuver of the agonist followed by a maximum isometric contraction of the stretched muscle (agonist). The final maneuver is a ten second, passive stretch of the agonist. The hold-relax technique can be used when the muscle to be stretched (agonist) is normal, without existing trauma. This can be determined following an injury through an evaluation depicting no marked difference in joint range of motion of the segment when compared to the opposite extremity.

Contract-relax. The contract-relax flexibility technique is initiated with a passive prestretch of the agonist and subsequent passive stretch of the agonist coupled with a submaximal concentric contraction of the antagonist. A final passive, static stretch of the agonist is held for ten seconds. This technique is especially beneficial to the athlete in the early stages of rehabilitation following an injury to the agonist. A passive stretch of the agonist and a concentric contraction of

the antagonist will often embody lower agonist muscle tension and promote relaxation of the muscle to be stretched (agonist). Muscle contractures are reduced and joint range of motion is better maintained when this stretching procedure is utilized as soon as possible after bleeding has ceased. Cornelius and Jackson (1984) indicated cold applied to the agonist muscle prior to the use of the contract-relax flexibility technique resulted in significantly greater joint range of motion than did a passive, static stretch without cold treatment. Although there are definite benefits to this stretching technique for the injured individual, Cornelius and Hinson (1980) reported that the addition of the concentric contraction of the antagonists in a no-cold condition increases effectiveness, but its combined presence does not significantly effect flexibility over other PNF techniques.

Slow-reveral-hold-relax. Slow-reversal-hold-relax flexibility technique is a combination of maneuvers from the two previous PNF techniques. The initial maneuver is a passive prestretch of the agonist muscle followed by a three second isometric contraction of the agonist. A passive stretch of the agonist is coupled with a submaximal concentric contraction of the antagonist muscle. A subsequent passive, static stretch of the agonist held for ten seconds terminates the technique. This PNF flexibility technique can be utilized when the athlete is attempting to increase joint range of motion with non-traumitized soft tissue involvement. If an injury has occured to the specified area, it is practical to wait until there is no marked

difference in range of motion between the involved and opposite joints. Although the slow-reversal-hold-relax technique will increase flexibility, it has not been shown to be significantly greater than other PNF techniques. More supervision, however, appears to be necessary when using this technique.

Summary

The benefits derived from optimum flexibility are multifaceted and when contemporary techniques are utilized the results are more dramatic. Although there are stretching techniques that take less time and flexibility maneuvers requiring less supervision, there are no scientifically substantiated techniques which provide greater range of motion than do modified PNF flexibility procedures.

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